How to prevent concussions in football? Better helmets

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UC Biomedical engineering student Christopher Boles uses a modal hammer to strike a dummy head containing accelerometers. By comparing the force the dummy registers with and without a helmet, researchers can see which helmets provide better protection from potential concussions. Credit: Andrew Higley

Football helmets made by four leading manufacturers showed

vulnerabilities in tests designed to better understand player concussions, according to a new study.

University of Cincinnati engineers put popular football helmets made by leading brands through impact testing and found that no single design demonstrated superior reduction of potential concussion incidence or consistent energy absorption at every part of the helmet.

Concussions from football are a health concern across all age groups from youth sports to professional leagues.

The NFL saw a dramatic increase in concussions during the 2022 season. Concussions were up 18% over the previous season, including high-profile players such as Cincinnati Bengals' receiver Tee Higgins.

"We're not trying to get kids to stop playing football," said Eric Nauman, a professor of biomedical engineering in UC's College of Engineering and Applied Science. "We just want them to be able to play without suffering long-term consequences."

The study was published in the *Journal of Biomechanical Engineering*.

The study was led by Nauman's former students Kevin McIver and Patrick Lee, along with UC's Sean Bucherl.

Researchers tested three helmets from each of nine models made by four companies.

"We came up with a test on our own based on some military projects we've done," Nauman said. "We can quantify exactly how much of the impact gets attenuated by the helmet."

They measured the mass of each helmet, an important consideration in

determining how much force is applied during a hard tackle or impact with the ground.

Each helmet was fit per manufacturer's instructions onto a dummy similar to the kind used in automotive crash testing. The dummy contains sensors called accelerometers that measure how fast the head moves upon impact.

Using an instrument called a modal hammer that contains sophisticated sensors to measure applied force accurately, researchers delivered 20 blows by hand at seven impact points around the dummy's bare head and its head while wearing each of the 27 helmets.

By measuring force applied to the dummy with and without the helmets, researchers were able to single out the strengths of each helmet design at each impact point. All four brands scored highest in minimizing impact in at least one of the impact points measured.

UC Biomedical engineering student Shengming Hu uses a modal hammer to strike a dummy head containing accelerometers. By comparing the force the dummy registers with and without a helmet, researchers can see which helmets provide better protection from potential concussions. Credit: Andrew Higley

Helmets were able to mitigate between 52% and 83% of the translational acceleration—or change in velocity—researchers measured in the hammer strikes. The back of the helmets fared worst in testing, reducing less than half the rotational acceleration of hammer strikes.

"None of the helmets was uniformly good or uniformly bad, except on the back of the helmet where they were all uniformly bad," Nauman said. "We didn't expect the helmets would be so bad in that one place."

Several well-known NFL players, including Miami Dolphins quarterback Tua Tagovailoa, sustained concussions when the back of their head hit the turf.

Researchers noted that lab tests alone are insufficient in determining what level of mitigation provides the best protection for particular athletes. They suggested field-based impact tracking in combination with lab tests could be more useful in future assessments.

Once the force ranges are better characterized, the shell and padding can be designed to maximize energy absorption and reduce the majority of unrestricted or sudden head movements, researchers said.

Credit: Andrew Higley

Students struck the helmets at different points to determine how much force they mitigated. Credit: Andrew Higley

Nauman said helmet padding that provides more absorption from impacts might offer better protection from concussions than a more rigid type. Likewise, he said some of the more flexible helmet shells improved energy absorption from the repetitive hits typical of football.

"There are a lot of ways to fix it," Nauman said. "The helmets are generally designed to withstand the maximum possible impact. But that's a 99th percentile type of hit. If you can design a helmet to protect players from the smaller, more typical hits, that would be ideal."

Nauman said even modest design changes could have profound benefits for players.

"I don't care as much about the NFL. Our audience is mostly high school or under—the 98 percent of players who don't play after high school," Nauman said. "If we can keep them safer through high school, that would be great."

More information: Kevin McIver et al, Design Considerations for the Attenuation of Translational and Rotational Accelerations in American Football Helmets, *Journal of Biomechanical Engineering* (2023). DOI: 10.1115/1.4056653

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